INSTRUCTIONS

GEI-88846A
Supersedes GEI-88846

TYPE 4701 TRANZDUCER for WATT AND VAR MEASUREMENTS

PROPERTY OF
SCHENECTADY
INSTRUMENTATION SERVICE
GENERAL ELECTRIC

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INTRODUCTION

The Type 4701 Watt and Var TranZducers described herein are AC/DC units designed to convert a-c input power to a proportional d-c milliampere output which can be measured and indicated by d-c instruments and/or recorders. The transducers covered in these instructions are: Cat. No. 50-470121AWAA1, a single-element unit to measure two-wire, single-phase watts; and Cat. No. 50-470122AWAA1, a double-element unit to measure three-wire, three-phase watts (or vars). For other polyphase power measurements, combinations of single-element (one-element) and double-element (two-element) units may be used. Accessory phase-shifting transformers are connected to transducer Cat. No. 50-470122AWAA1 when the unit is used to measure vars.

All electrical components (except transformers) are mounted on a printed-circuit board (called an element), thus providing ready accessibility for checking or replacement. When connected to an a-c power system, the element is isolated from the a-c input by internal potential and current transformers having nominal input ratings of 120 volts and 5 amperes, respectively.

The standard output of a single measuring-circuit element is 1.0 milliampere into 2200 ohms at 500 calibrating watts (or vars). Since the outputs of two or more elements are connected in series, the output of two elements is 1.0 milliampere into 4400 ohms, and the output of three elements is 1.0 milliampere into 6600 ohms. Typical direct acting milliammeters which may be connected to the standard output of a circuit element include Types 180, DO-91, DB-18, and DB-30 indicators; or Types CF and CH recorders.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

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TABLE I

SPECIFICATIONS

Power Input	
Potential Circuit	120V, 60 cps (50 cps)
Current Circuit	0 to 5 amperes
Standard Output	1 ma DC; into external load of 2200 ohms per element at input of 500 calibrating watts per element (or vars); output adjustable ±10%
Accuracy	±0.5% standard output
Response Time	0.5 second maximum to within 99% of final value
Ambient Temperature	-20C (-4F) to +60C (+140F) (maximum temperature coefficient: 0.05% per degree Centigrade)
Burden	
Potential Circuit	2.4 volt-amperes per element
Current Circuit	1.8 volt-amperes per element
Output Ripple	Approximately 25% r.m.s. This is reduced to 0.1% peak-to-peak by the use of a filtered watt transducer adaptor accessory.
Overload	
Potential Circuit	20% greater than rated voltage, continuously
Current Circuit	15 times greater than rated current, for 10 seconds applied not oftener than once per hour (continuous cycling not recommended) or 2 times greater than rated current, continuously,
Dielectric Test	2600V AC rms between primary (input) circuits to secondary circuit and to ground.

Watt transducer adaptors (millivolt voltage dividers) are available as accessories (either as unfiltered or filtered units) for connection to the standard milliampere output terminals. The unfiltered (approximately 25% r.m.s.) unit includes 50, 100, and 800 millivolt output signals that can be used for instruments such as the Type HP-31 indicators; Types HF, HG, HL, HR and HT null-balance recorders; and Type TF-9 telemeter transmitters. The filtered (0.1% ripple, peak-to-peak) unit includes 40, 100, and 800 millivolt output signals that can be used particularly for computer applications where low ripple is required. Details for selecting and connecting the watt transducer adaptors are contained in the Installation instructions and illustrated in Fig. 8 through Fig. 10.

TABLE II

ACCESSORIES* - WATT TRANSDUCER ADAPTORS

Description	Circuit to be used in	No. of Elements being used	Outputs (Millivolts)	Cat. No.
Unfiltered (25% r.m.s.) with millivolt output terminals	1 Phase, 2 Wire	1	50, 100, and 800	50-470271CDAA1
	3 Phase, 3 Wire	2	50, 100, and 800	50-470273CDAA1
	3 Phase, 4 Wire	3	50, 100, and 800	50-470275CDAA1
Filtered (0.1% ripple, peak-to-peak) with millivolt output terminals	1 Phase, 2 Wire	1	40, 100, and 800	50-470270CFAA1
	3 Phase, 3 Wire	2	40, 100, and 800	50-470272CFAA1
	3 Phase, 4 Wire	3	40, 100, and 800	50-470274CFAA1

*The accessories above are available when millivolt outputs are required; order separately by General Electric number. Other millivolt levels are available; order by describing millivolts desired and stating whether filtering is desired.

TABLE III

ACCESSORIES - PHASE SHIFTING TRANSFORMERS

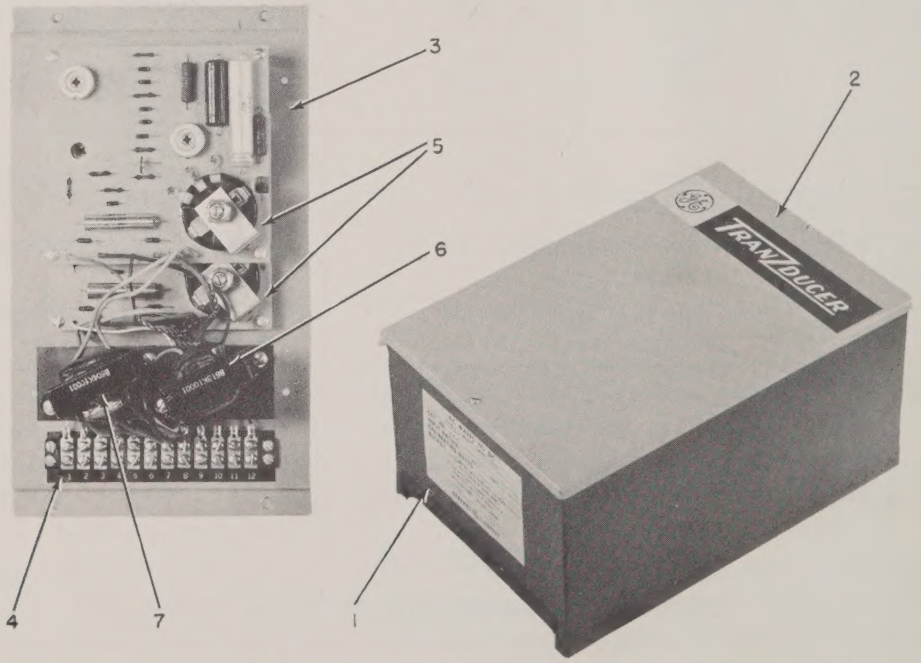
Polyphase Application	Type	Catalog Number
3 Phase, 3 Wire	MC-63	700X84G1
3 Phase, 4 Wire	MC-65	700X85G1

The response time of a transducer is 99% in 0.5 second max; that is, the d-c output rises to 99% of its final value in 0.5 second max. In general, this response time is considerably faster than that of the associated measuring instruments and recorders.

Table I lists the transducer specifications. Accessory watt transducer adaptors are listed in Table II, and accessory phase-shifting transformers are listed in Table III.

RECEIVING, HANDLING AND STORAGE

On receipt of a transducer, examine it immediately for any damage that may have occurred in transit. Immediate examination is especially important if rough handling is evident. If damage is found, a claim should be filed immediately with the transportation company, and the nearest General Electric sales office should be notified. Avoid rough handling when unpacking. If a transducer is to be stored prior to installation, protect it from moisture, dirt, corrosive atmosphere, and mechanical damage.



1. Case
2. Cover
3. Support Plate
4. Terminal Board
5. Printed Circuit Board
6. Potential Transformer
7. Current Transformer

Fig. 1. Type 4701 Watt-Var/DC Transducer

DESCRIPTION

The transducer (see Fig. 1) is 11-1/2 inches long by 5 inches high by 6-3/4 inches wide for switchboard type mounting. It consists of one or two elements in a case assembly with a removable cover. A circuit label (for component location purposes) is attached to the underside of the cover.

The printed circuit board (see Fig. 14) supports all the electrical components of the measuring circuitry (see Fig. 15), with the exception of the transformers. Three potentiometer controls are located on top of the printed circuit board: SPAN ADJ FOR CALIBRATION R1 and R2 for linearity control; and ZERO ADJ R9 for null-balance control. Potentiometer R2 should be locked after it has been adjusted.

Fig. 1 illustrates a two-element transducer. The difference between the one-element and two-element transducers is that the two-element unit contains two measuring circuits consisting of two elements, two potential transformers, and two current transformers. When a transducer, Cat. No. 470122AWAA1, is used for var measurements, phase-shifting transformers must be connected to the unit.

INSTALLATION AND OPERATION

GENERAL

The one-element transducer, Cat. No. 50-470121AWAA1, is used to measure power in single-phase, two-wire circuits. The two-element unit, Cat. No. 50-470122AWAA1, is used to measure power in three-phase, three-wire circuits. For other polyphase circuits, a combination of both one-element and two-element units must be used. For example, on three-phase four-wire circuits, three elements must be used: one one-element unit plus one two-element unit, or three one-element units. When var measurements are being made, phase shifting transformers (see Table III) must be applied to the transducer inputs.

The d-c output from the transducer is designed for use with various measuring devices. Standard d-c output is 1.0 milliampere for 500 calibrating watts (or vars) input. The external measuring circuit is 2200 ohms multiplied by the number of elements used. When the measuring instrument has a lower internal resistance than this, a series resistor must be included in the circuit to achieve the required resistance.

IMPORTANT

Before installing the transducer into the power system, calculate the calibrating watts and d-c output by referring to the Maintenance instructions.

MOUNTING

Outline and mounting dimensions of the transducer are shown in Fig. 2. The unit may be mounted in any position.

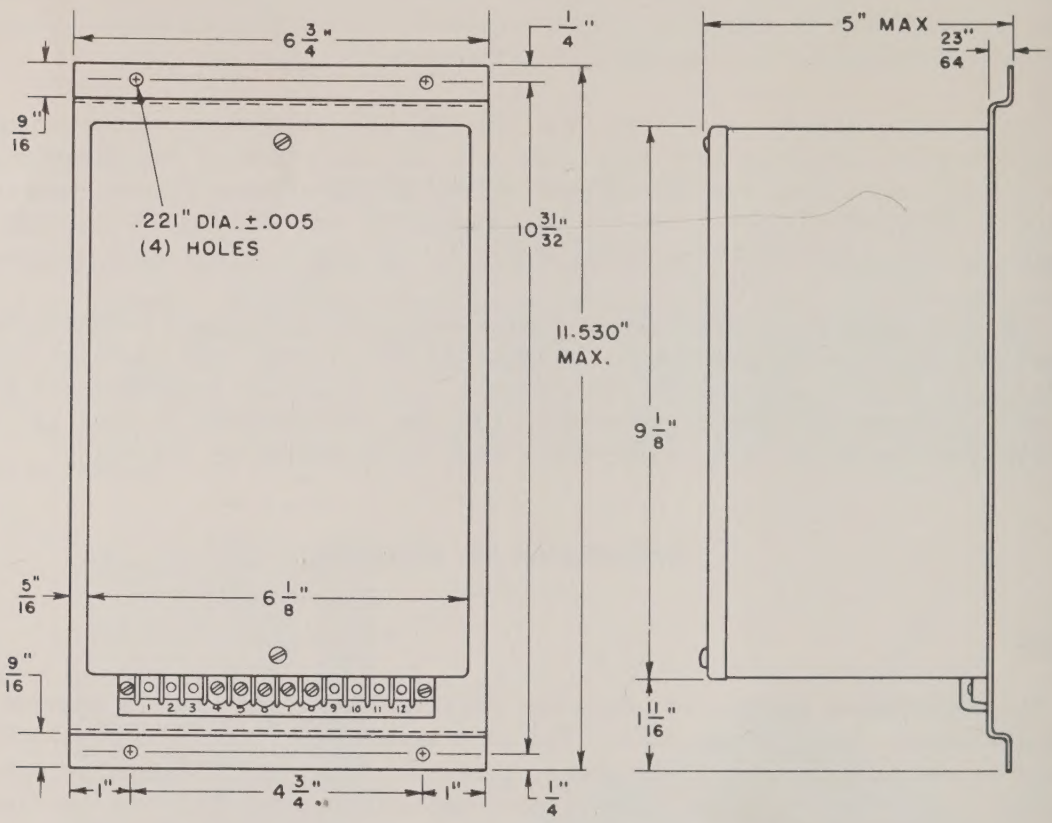


Fig. 2. Dimensions of transducer

CONNECTIONS

Fig. 3 through Fig. 7 are external connection diagrams for the transducers. When the connections are made as shown, the d-c output polarity is positive (+) at TB-12 and negative (-) at TB-1. The output circuits are isolated from inputs by 2600 volt insulation in the transformers which have a primary-to-secondary leakage resistance of over 200 megohms. Hence, the outputs may be operated with either + or - grounded or ungrounded, at the discretion of the user. However it is recommended that the negative terminal of single and two element transducers be grounded for other than totalizing circuits. The essential requirement is that ground and insulation levels in the output circuit exclude significant additions to, or subtractions from the output current.

IMPORTANT

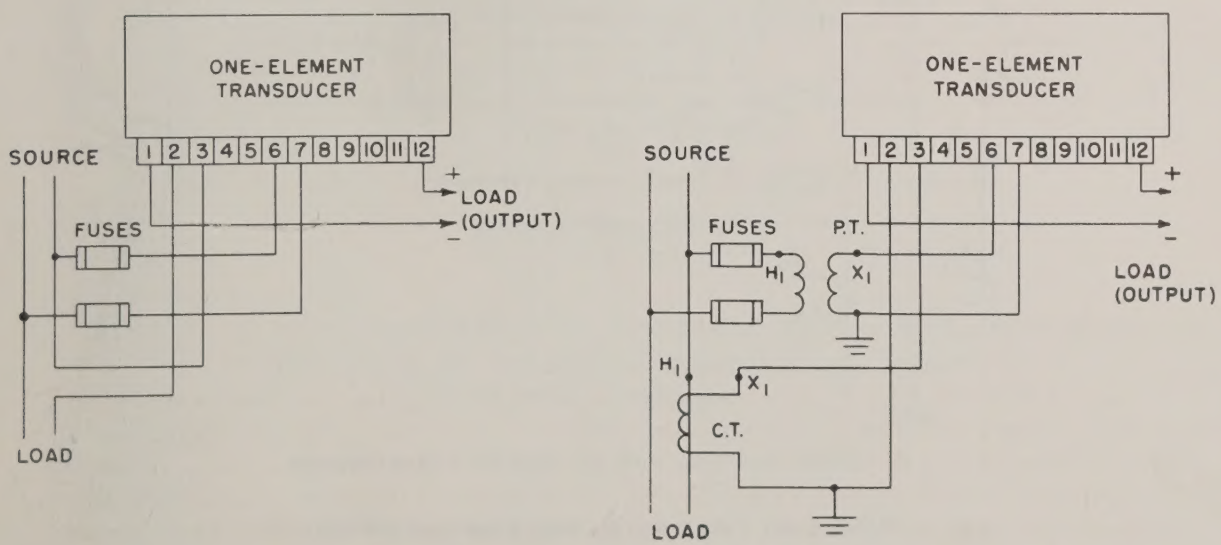
Connection diagrams assume a phase sequence 1-2-3. If output instrument (normally zero-center, with "out" side to right) shows "in" and "out" reversed, then proceed as follows:

1. In the case of an installation containing a two-element transducer, correct by reversing connections to terminals "6" and "7", and also to terminals "8" and "9".

2. In the case of an installation containing both a one-element and a two-element transducer, correct by reversing terminals as per steps 1 and 3, respectively.

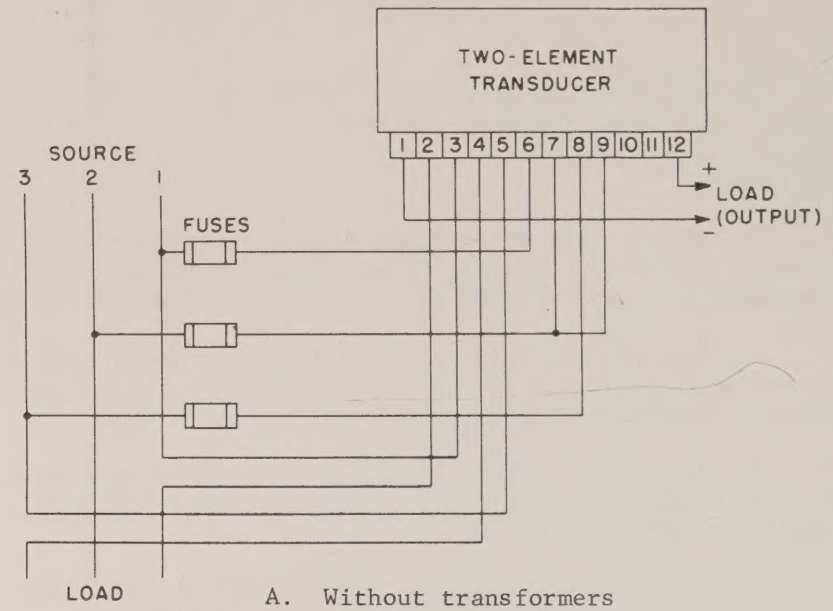
3. In a single-phase installation containing a one-element transducer, correct by reversing connections to terminals "6" and "7".

A phase-sequence indicator may be used to check the phase sequence of polyphase inputs. The following General Electric instruments are available for this purpose: Cat. No. 5467032G5, for polyphase inputs of 107-625 volts at 60 cps; Cat. No. 5467032G8, for polyphase inputs of 107-625 volts at 50 cps; Cat. No. 5467032G6, for polyphase inputs of 107-625 volts at 400 cps.

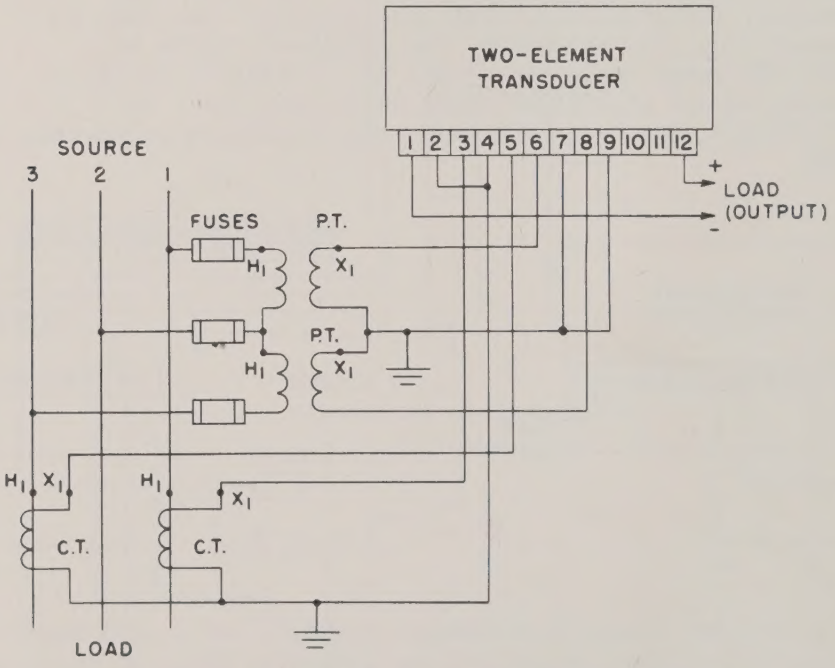


A. Without transformers B. With current and potential transformers

Fig. 3. External connections for measurement of two-wire, single-phase watts



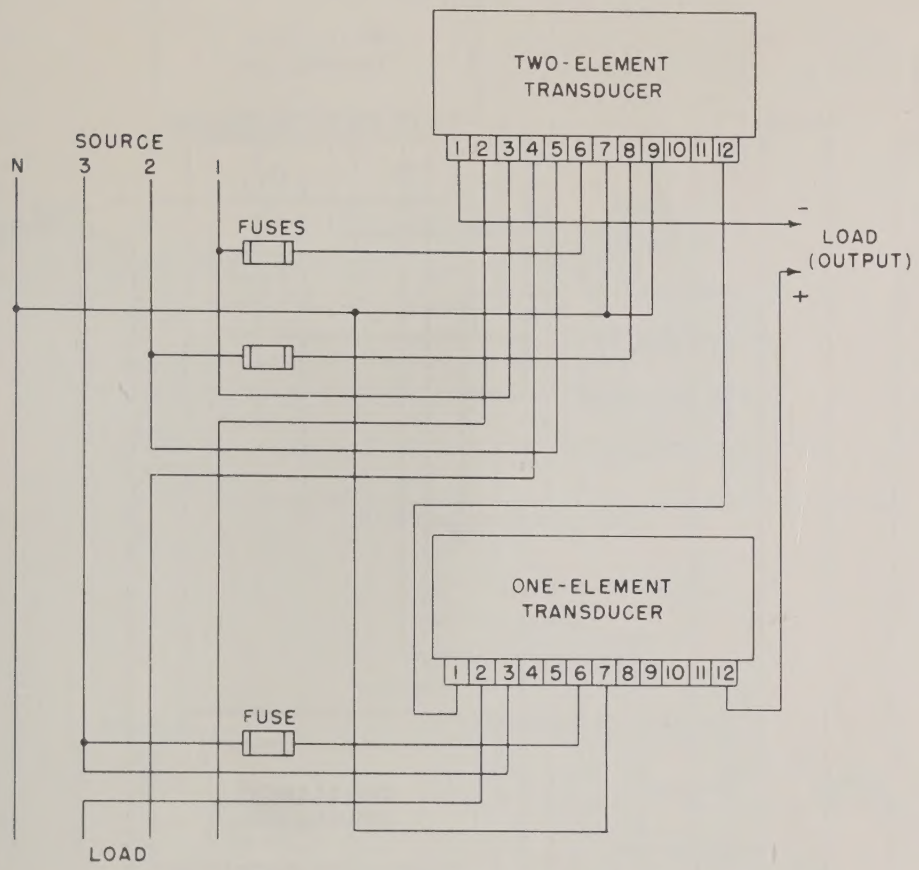
A. Without transformers



B. With current and potential transformers

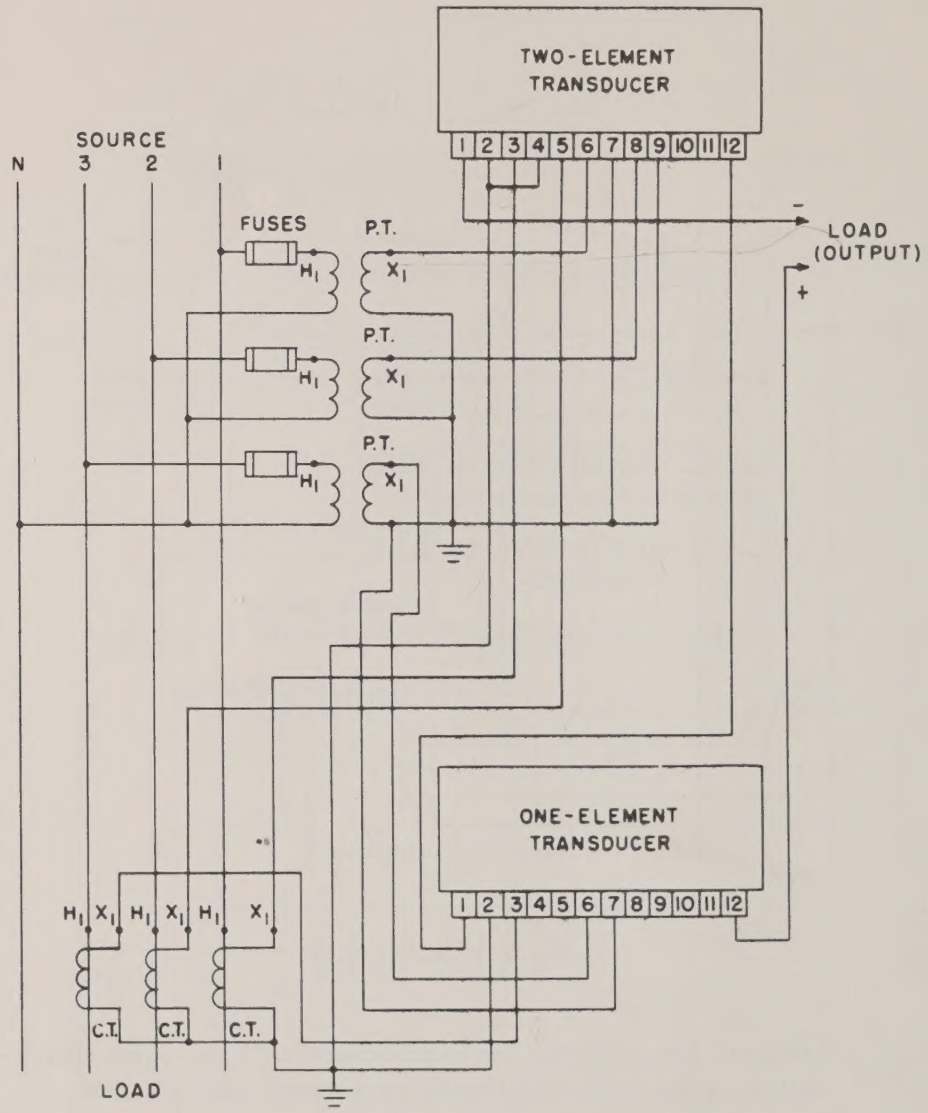
NOTE: On three-wire, two-phase circuits, line 2 is common.

Fig. 4. External connections for measurement of three-wire, three-phase, and three-wire, two-phase watts using one two-element transducer



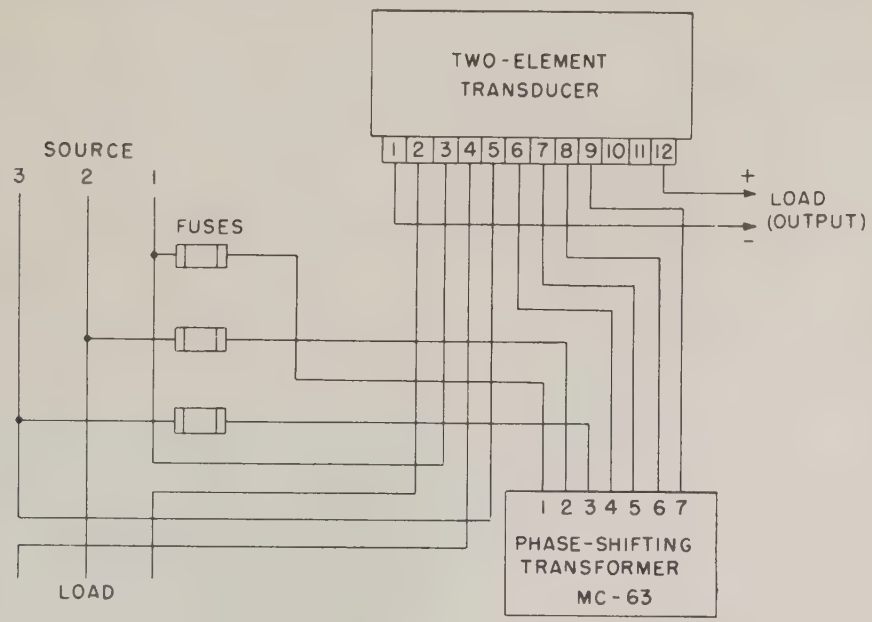
Without transformers

Fig. 5A. External connections for measurement of four-wire, three-phase watts using one one-element transducer and one two-element transducer

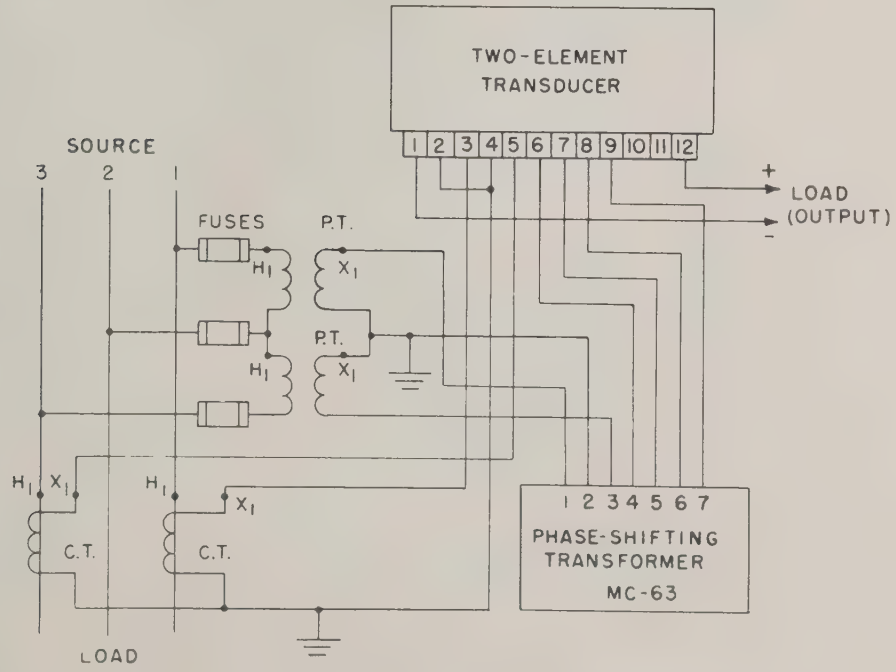


With current and potential transformers

Fig. 5B. External connections for measurement of four-wire, three-phase watts using one one-element transducer and one two-element transducer

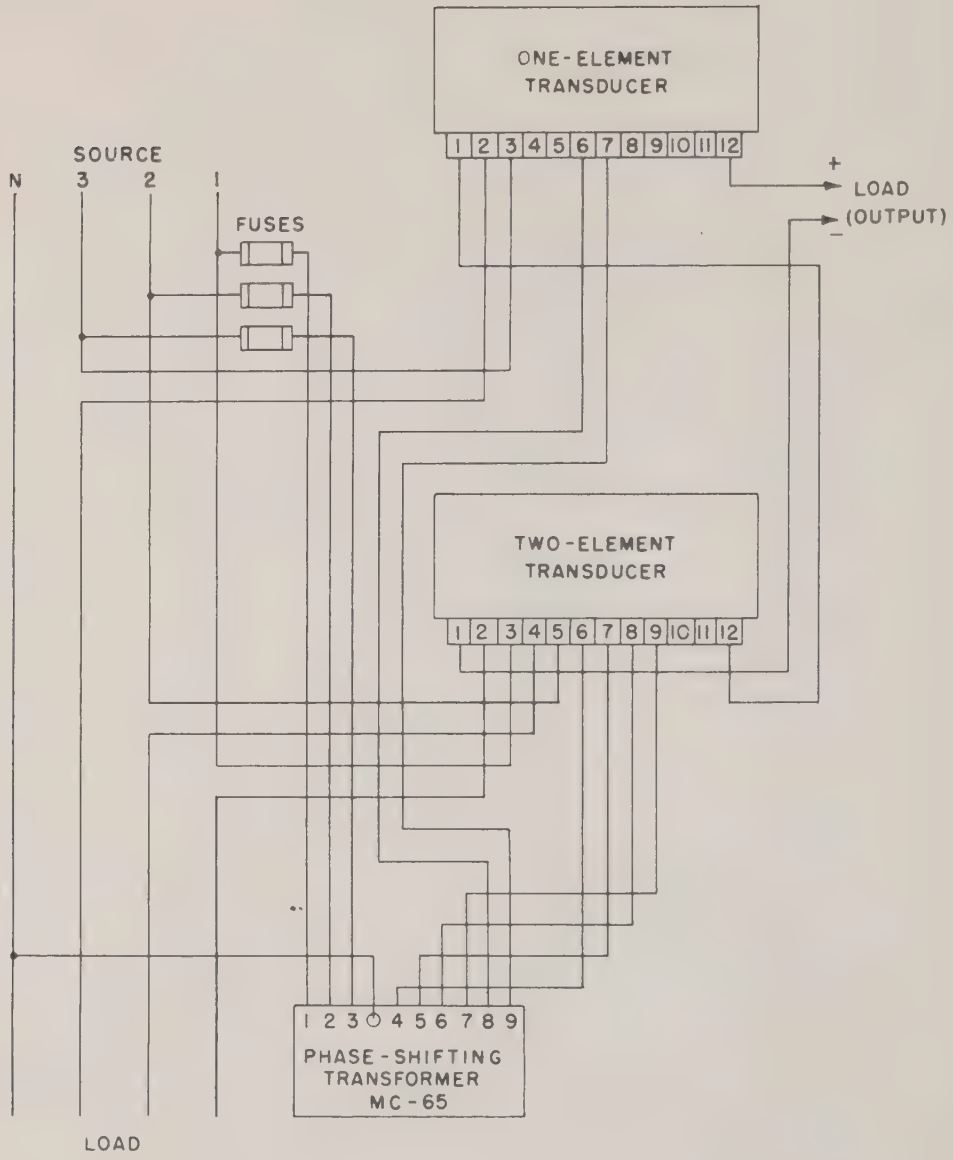


A. Without transformers



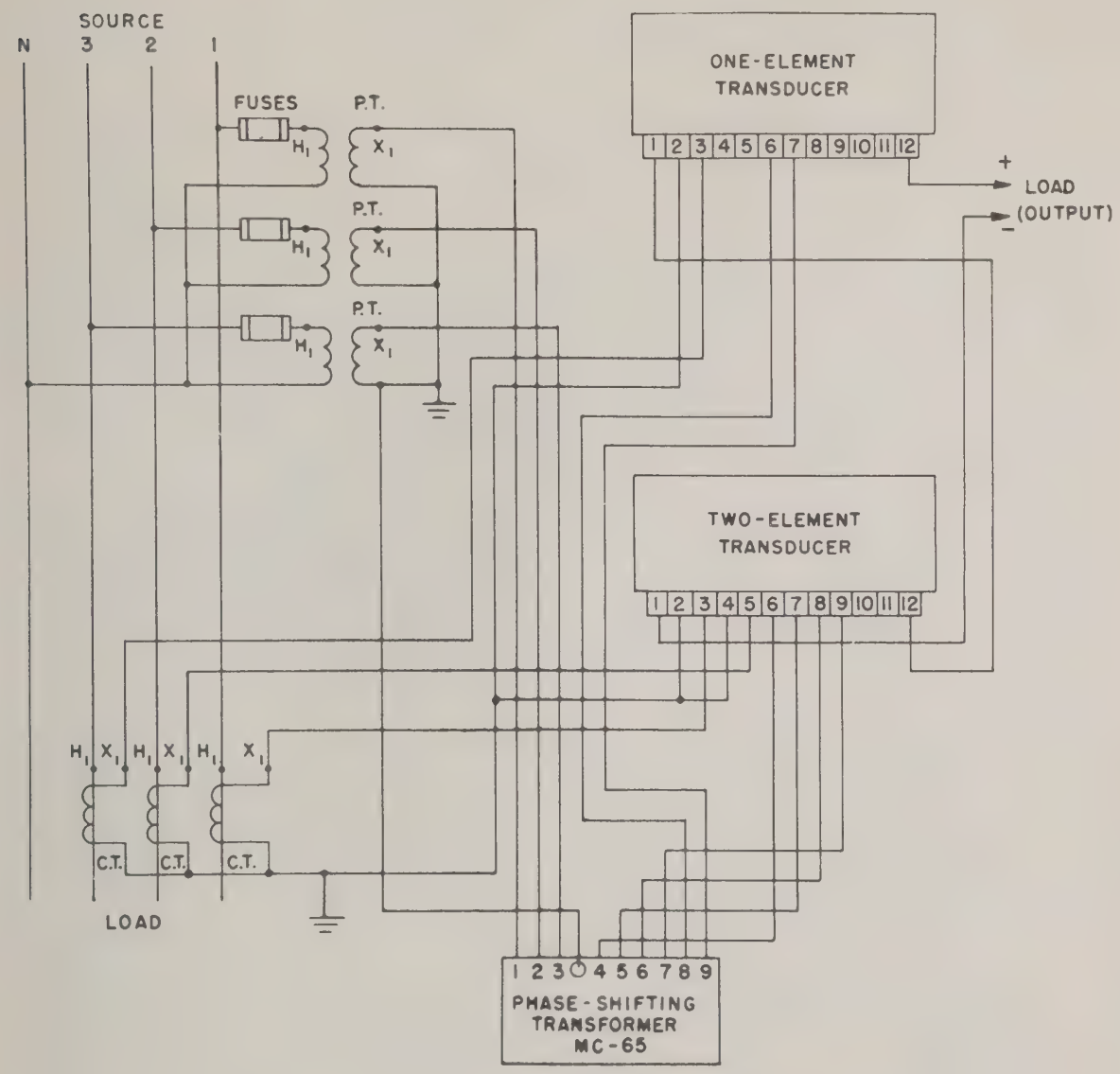
B. With current and potential transformers

Fig. 6. External connections for measurement of three-wire, three-phase vars using one two-element transducer and one phase-shifting transformer



Without transformers

Fig. 7A. External connections for measurement of four-wire, three-phase vars using one one-element transducer, one two-element transducer, and one phase-shifting transformer



With current and potential transformers

Fig. 7B. External connections for measurement of four-wire, three-phase vars using one one-element transducer, one two-element transducer, and one phase-shifting transformer

WATT TRANSDUCER ADAPTORS

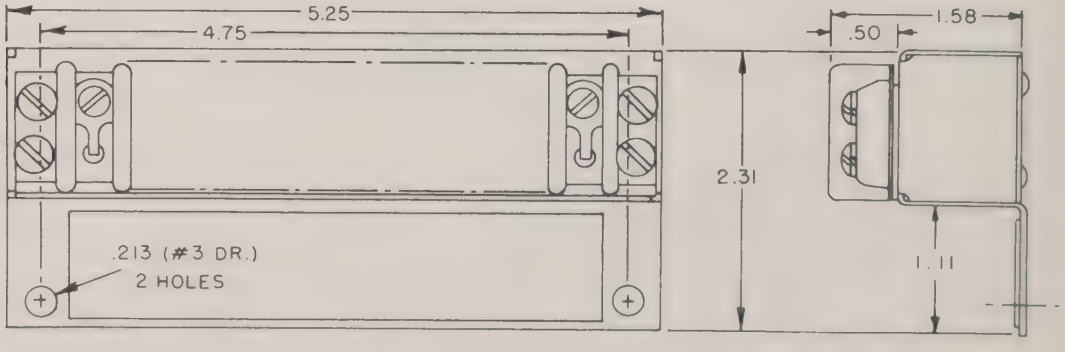
Watt transducer adaptors are accessories which can be connected to the transducer terminal boards to provide the millivolt outputs listed in Table II. The use and connections of watt transducer adaptors can best be shown by reference to Fig. 8 through Fig. 10.

When connecting an adaptor to the standard milliampere output terminals of a transducer, it must be remembered that the total resistance between the minus (-) input terminal "1" and plus (+) input terminal "10" must be equal to 2200 ohms multiplied by the number of elements used. If one element is used (single-phase, two-wire circuit), then the total resistance is 2200 ohms; if two elements are used (three-phase, three-wire circuit), then the total resistance is 4400 ohms; if three elements are used (three-phase, four-wire circuit), then the total resistance is 6600 ohms. Referring to Fig. 9, the R4 resistance must be equal to 1400 ohms to total 2200 ohms between terminals "1" and "10" for single-phase, two-wire circuits; the R4 resistance must be equal to 3600 ohms to total 4400 ohms between terminals "1" and "10" for three-phase, three-wire circuits; the R4 resistance must be equal to 5800 ohms to total 6600 ohms between terminals "1" and "10" for three-phase, four-wire circuits. The same reasoning applies to Fig. 10.

A 0-1.0 milliampere full-scale indicator, with an internal resistance of 700 ohms ±2.2 ohms, can be connected between terminals "7" and "8" of either adaptor for indicating purposes. In this case, the jumper between terminals "7" and "8" must be shifted over to terminals "7" and "6". This action shorts out R3 (700 ohms) and the total output-circuit resistance is not upset.

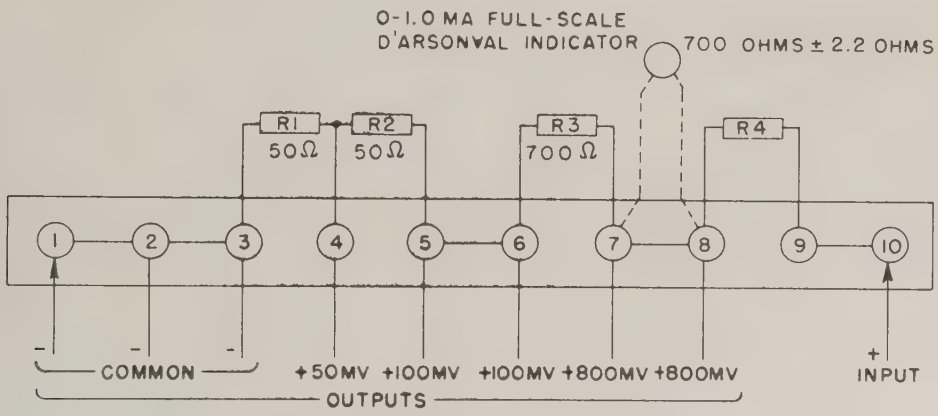
TELEMETERING APPLICATION

Potentiometric devices such as telemetering transmitters can be interconnected with a transducer through the low impedance sections (50, 100, and 800 millivolts) of the unfiltered adaptors. For direct-wire telemetering application, the resistance of the transmission lines must be included as a part of the 2200 ohms-per-element output-circuit resistance. A change of 1% in this resistance (22 ohms for a single-element transducer, or 44 ohms for a two-element transducer) may cause a 0.7% change in transducer accuracy.



NOTE: Adaptor may be separately mounted, or mounted with transducer, using common mounting holes on terminal board end of transducer.

Fig. 8. Dimensions of watt transducer adaptors.



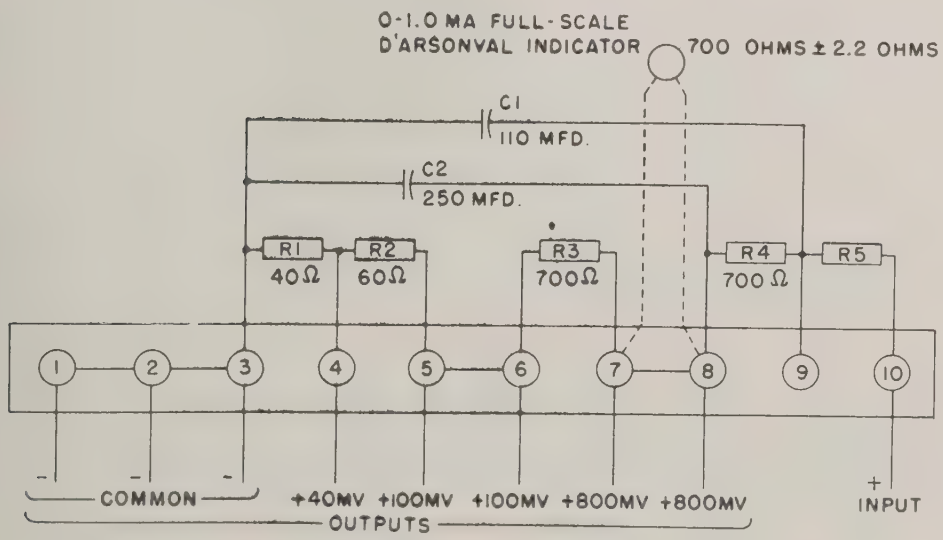
NOTE: R4 equals:

1400 ohms for 1 phase, 2 wire circuits (Adaptor Cat. No. 50-470271CDAA1)

3600 ohms for 3 phase, 3 wire circuits (Adaptor Cat. No. 50-470273CDAA1)

5800 ohms for 3 phase, 4 wire circuits (Adaptor Cat. No. 50-470275CDAA1)

Fig. 9. Watt transducer adaptor, unfiltered



NOTE: R5 equals:

700 ohms for 1 phase, 2 wire circuits (Adaptor Cat. No. 50-470270CFAA1)

2900 ohms for 3 phase, 3 wire circuits (Adaptor Cat. No. 50-470272CFAA1)

5100 ohms for 3 phase, 4 wire circuits (Adaptor Cat. No. 50-470274CFAA1)

Fig. 10. Watt transducer adaptor, filtered

INITIAL ADJUSTMENTS

Transducers are adjusted at the factory prior to shipment for standard d-c output of 1 milliampere into a 2200 ohm load per element, with an input of 500 calibrating watts (or vars). Since the d-c output of a transducer is essentially linear over the operating range, limited between 250 to 625 calibrating watts (or vars) power input, no initial adjustments should be required during installation. If subsequent operation after installation indicates trouble, refer to the Maintenance instructions for calibration procedures.

PRINCIPLES OF OPERATION

GENERAL

The transducer produces a d-c output proportional to an a-c power input. This conversion of AC to DC is accomplished by means of a Zener diode exponential section in conjunction with associated circuitry. The d-c output is used as the input signal for various d-c measuring devices. The complete circuit is shown schematically in Fig. 15.

CIRCUIT DESCRIPTION

The circuit shown in Fig. 11 is a simplified version of Fig. 15, where the Zener diode exponential section represents diodes CR3 thru CR8 and resistors R5 through R7. The circuit consists primarily of:

1. Zener diode exponential section.

2. Resistance R_S which represents the total linear resistance in series with the Zener diode exponential section to obtain the relation $I = KV^2$, where I is alternately equal to I_1 and I_2.

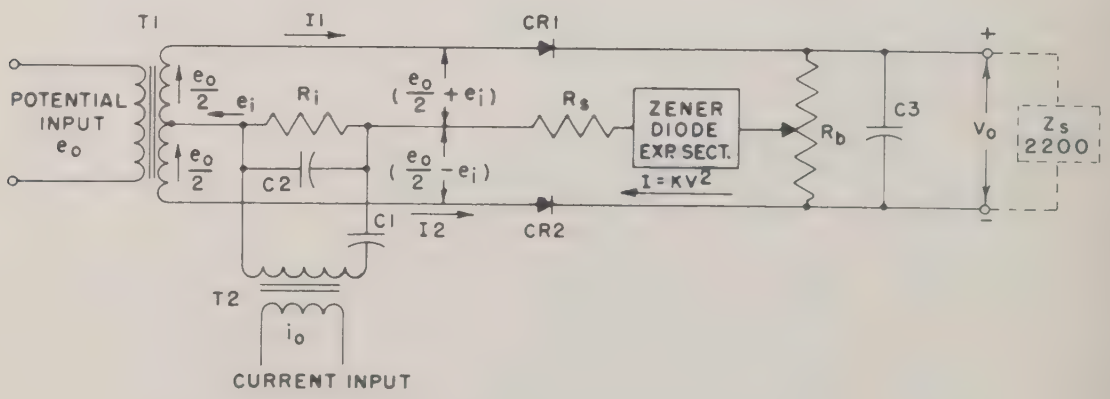


Fig. 11. Simplified schematic

3. Potential transformer T1 with 1/1 ratio.

4. Current transformer T2 with 100/1 ratio.

5. Resistance R_i (representing R1, R2, R12) for injection of a voltage signal e_i proportional to input current i_o.

6. Diodes CR1 and CR2 for rectification of the branch currents I_1 and I_2, respectively.

7. Capacitor C1 acting as a blocking capacitor to eliminate errors due to DC which would otherwise circulate in the secondary of T2.

8. Capacitor C2 acting to correct for phase differences between the voltage and current transformers at unity power factor.

9. Capacitor C3 acting as a smoothing capacitor to reduce the a-c ripple content in the d-c output.

10. Potentiometer R_b serving as a balancing resistance to null the output at normal voltage, no current condition.

11. Thermistor RT1 (see Fig. 15), rated 250 ohms at 25C (77F). Since the conductance of the Zener diode exponential section decreases with reduction in temperature, a series section having a negative temperature coefficient is required. The temperature compensation consisting of thermistor RT1 shunted by fixed resistor R3 keeps the transducer within 0.5% at an ambient temperature range of -20C (-4F) to +65C (+140F).

Now consider the case where only potential e_o is applied to the transducer through transformer T1. Branch currents I_1 and I_2 are equalized by potentiometer R_b and the output is zero.

If current is now applied to transformer T2, a voltage e_i proportional to i_o appears across R_i. The voltage ($e_o/2$ each) across the T1 secondary combine with the voltage e_i across R_i such that the voltage across the top branch equals $e_o/2 + e_i$, and the voltage across the bottom branch equals $e_o/2 - e_i$.

On the positive half cycle of operation, the voltage $e_o/2 + e_i$ is applied across the Zener diode exponential section in series with R_S. The current I_1 is then proportional to the square of the voltage drop; that is, $I_1 = K_1 (e_o/2 + e_i)^2$, where K_1 equals a constant value. On the negative half cycle of operation, $e_o/2 - e_i$ is applied, and $I_2 = K_1 (e_o/2 - e_i)^2$.

The terminal voltage V_o is equal to the algebraic difference in voltages appearing across each half of R_b. The voltage across the top half is equal to

$(R_b/2)\ I_1$ and that across the bottom half is equal to $(R_b/2)I_2$. The algebraic difference of these two voltages is $V_o = R_b/2\ (I_1 - I_2)$.

In the transducer standard output, the average difference of $I_1 - I_2$, from $V_o = R_b/2\ (I_1 - I_2)$, is measured by a direct-reading milliammeter. This reading is a valid measurement of power as shown below.

If the expressions for $I_1 = K_1\ (e_o/2 + e_i)^2$ and $I_2 = K_1\ (e_o/2 - e_i)^2$ are substituted into the expression for terminal voltage $V_o = R_b/2\ (I_1 - I_2)$, then the terminal voltage expression can be reduced to $V_o = 2K_1(e_o e_i)$. The integrated average of $V_o = 2K_1\ (e_o e_i)$ is $V_o = K_2 P$, where K_2 is a constant and P is average power. Thus the input voltages e_o and e_i result in an output of V_o which is proportional to average power.

To measure three-phase reactive power (vars), the input potentials must first be shifted in phase by 90 degrees. Then the d-c output of the transducer is proportional to the input reactive power.

MAINTENANCE

GENERAL

The transducers need no maintenance since they consist of conventional solid state components.

COMPONENT REPLACEMENT

If trouble occurs, refer to the Trouble Shooting instructions and replace components with the parts listed in the Repair Parts instructions. In particular, note that Zener diodes CR3 through CR8 are selected components whose values are determined at time of manufacture.

CAUTION

Be sure to observe proper polarity when connecting diodes (see Fig. 14), and correct color coding of the leads when connecting transformers into circuitry (see Fig. 15).

CALIBRATING WATTS (OR VARS)

The value of calibrating watts (or vars) is the input power required by a transducer for full-scale indication of the measuring instrument or recorder when connected in the calibrating circuit without external potential or current transformers.

In the calibration of transducers, it is customary to utilize a single-phase, unity-power-factor source. During calibration of two-element transducers, the primaries of the internal potential transformers (T1) are connected in parallel across the single-phase circuit, and the primaries of the internal current transformers (T2) are connected in series. The output of the polyphase transducer is then the sum of the voltages produced by the two elements.

When a transducer is used with external transformers, the external transformer ratios must be considered.

The following formulas give the relation for calibrating watts (or vars) when a transducer is calibrated on a single-phase system as previously described: for a one-element transducer in a single-phase, two-wire circuit,

$$\text{Calibrating watts (or vars)} = \frac{\text{full-scale watts (or vars)}}{\text{P.T. ratio x C.T. ratio x 1}}$$

For a two-element transducer in a three-phase, three-wire circuit,

$$\text{Calibrating watts (or vars)} = \frac{\text{full-scale watts (or vars)}}{\text{P.T. ratio x C.T. ratio x 2}}$$

For a combination of one-element and two-element transducers (or three single-element transducers) in a three-phase, four-wire circuit,

$$\text{Calibrating watts (or vars)} = \frac{\text{full-scale watts (or vars)}}{\text{P.T. ratio x C.T. ratio x 3}}$$

In the above equations and in the following equations,

Full-scale watts (or vars) is the full-scale reading of the measuring instrument or recorder.

P.T. ratio is the turns ratio of the external potential transformers,

C.T. ratio is the turns ratio of the external current transformer,

K is the number of elements (1, 2, or 3) in the transducers.

Example: What are the calibrating watts for a one-element transducer when the external potential transformer has a ratio of 5/1 and the current transformer has a ratio of 40/1 in a single-phase, two-wire power system of 0 to 100 kilowatts?

$$\text{Calibrating watts} = \frac{\text{full-scale watts}}{\text{P.T. ratio x C.T. ratio x K}}$$

$$= \frac{100{,}000}{5/1 \times 40/1 \times 1}$$

$$= \frac{100{,}000}{200}$$

$$= 500 \text{ calibrating watts}$$

If the P.T. ratio above were increased to 10/1, then the calibrating watts would be equal to 250 watts; if the P.T. ratio were decreased to 4/1, then the calibrating watts would be equal to 625 watts.

CALCULATION OF TOTAL D-C OUTPUT

Calculate total d-c output (milliampere or millivolt) by the following equations:

$$\text{Total ma. output} = \frac{CW}{500} \times 1.00 \text{ ma.}$$

or

$$\text{Total mv output} = \frac{CW}{500} \times \text{W.T.A. mv}$$

where C.W. = calibrating watts (or vars)

W.T.A. = total millivolt output of watt transducer adaptors

Example: What is the total d-c milliampere output with an input of 500 calibrating watts

$$\text{Total ma. output} = \frac{CW}{500} \times 1.00 \text{ ma.}$$

$$= \frac{500}{500} \times 1.00 \text{ ma.}$$

$$= 1.00 \text{ ma.}$$

If the calibrating watts were equal to 250 watts, then the total milliampere output would be equal to 0.5 ma; if the calibrating watts were equal to 625 watts, then the total milliampere output would be equal to 1.25 ma. Thus an input range of 250 to 625 calibrating watts (or vars) results in a proportional output of 0.5 ma (1.1 volts across 2200 ohms) to 1.25 ma (2.75 volts across 2200 ohms).

ADJUSTMENTS

It is recommended that the following balance and linearity adjustments be made once per year.

NOTE: Before making the adjustments, check the insulation level of the transducer output circuit; the insulation resistance from terminal "12" to ground should be at least 2.2 megohms per element.

Connect the transducer to a source of rated voltage and current as per Fig. 12 (one-element unit) or Fig. 13 (two-element unit).

IMPORTANT

If an adjustable voltage source must be used for the test voltage, use an adjustable autotransformer. DO NOT use voltage-dropping resistors connected in series with the voltage source.

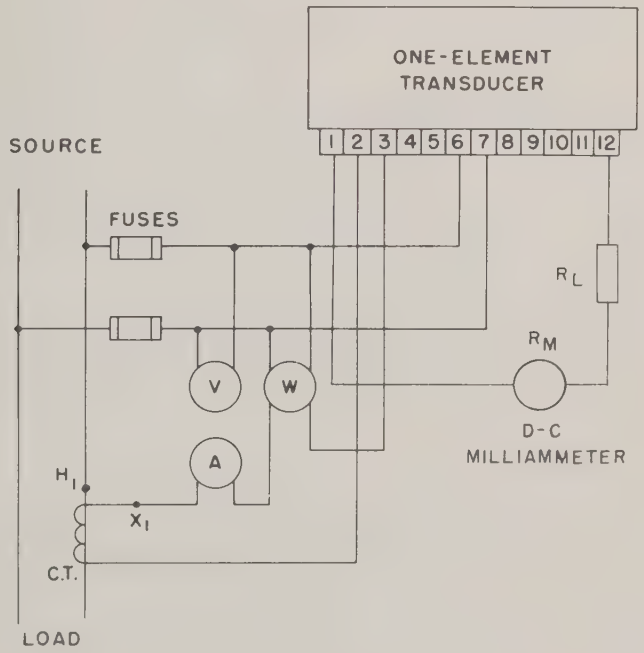


Fig. 12. Test connections for a one-element transducer

IMPORTANT

If an adjustable voltage source must be used for the test voltage, use an adjustable auto-transformer. DO NOT use voltage-dropping resistors connected in series with the voltage source.

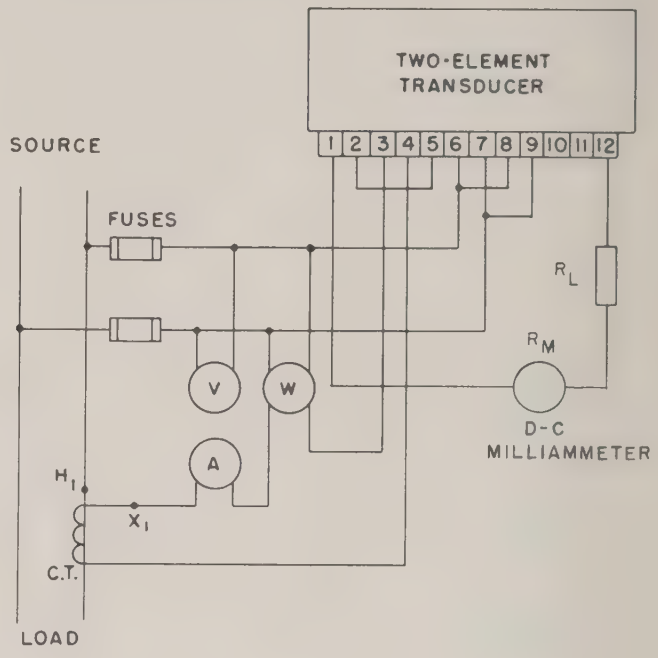


Fig. 13. Test connections for a two-element transducer

The power source must be stable, and capable of smooth adjustment from 0 to 500 calibrating watts (or vars) at 120 volts, 60 cps (harmonic content must not be greater than 5%). The 60 cps wave form should be sinusoidal and the volt-ampere capacity sufficient to minimize harmonic distortion due to non-linearity of the potential circuit. Since the potential circuit requires only 2.4 volt-amperes, a 50 volt-ampere potential source is ample.

The test equipment required is as follows:

A-c Voltmeter, 0-150V	General Electric Type AP-12
A-c Ammeter, 0-5A	General Electric Type AP-12
A-c Wattmeter, 0-600W	General Electric Type AP-12
D-c Milliammeter	General Electric Type DP-12 General Electric Cat. No. 581X49
Output Load ($R_M + R_L$)	2200 ohms ±2.7 ohms, single element 4400 ohms ±5.4 ohms, double element

IMPORTANT

If the user does not have the required test equipment as listed above, then transducer calibration can be checked by using only SPAN ADJ FOR CALIBRATION control R1 (see Fig. 14) to obtain the calculated d-c output into a load of 2200 ohms ±2.7 ohms.

One-element Transducer

Balance Adjustment - With potential alone applied, adjust ZERO ADJ control R9 (see Fig. 14) for null.

Span Adjustment - Apply 120 volts, 4.17 amperes (500 calibrating watts) (or vars). Then, adjust SPAN ADJ FOR CALIBRATION controls R1 or R2 (see Fig. 14) for an output of 1.000 milliampere. In general, it is usually necessary to adjust only R2 for this adjustment. Lock R2 after adjustment.

Two-element Transducer

Balance Adjustment - With potential alone applied on each element, adjust ZERO ADJ control R9 (see Fig. 14) for null.

Span Adjustment - With both potential circuits energized, apply current to bottom element only. Adjust SPAN ADJ FOR CALIBRATION control R2 for 0.500 milliampere into 4400 ohms. Then energize the top element current circuit, and adjust SPAN ADJ FOR CALIBRATION controls R1 and R2 for 1.000 milliampere.

TROUBLE SHOOTING

GENERAL

These instructions contain trouble shooting information for the transducer units described herein. The information assumes that the user is familiar with the proper operation of the units. Trouble shooting procedures consist of measuring a-c and d-c voltages at certain critical test points within the transducer. Abnormal readings will isolate the trouble area, and standard service techniques can then be used to locate a faulty component.

VOLTAGE MEASUREMENTS

Connect the transducer as per Fig. 12 or Fig. 13, as applicable. Then, using an ac/dc voltmeter, check voltage measurements as per Table IV, referring to Fig. 14 for component location and Fig. 15 for test points (for example, ① , ② , ③ , etc.)

TABLE IV

VOLTAGE MEASUREMENTS*

Voltmeter Connections		Volts (AC)	Volts (DC)	Remarks
From Test Point	To Test Point			
1	2	69		Measurements taken with 60 cps, 500 watt power: 120V to input of T1, and 4.17A input to T2.
1	3	69		
4	5	18.5		
6 +	1 -		62	
6 +	7 -		45	
6 +	9 -		3.3	Measurements taken with 4.17A removed from T2.
8 +	6 -		3.3	

*1. A-c voltages measured with 5000 ohms/volt a-c voltmeter.

2. D-c voltages measured with 20,000 ohms/volt d-c voltmeter.

3. If voltage measurements differ more than ±5% from typical values in Table IV, isolate and replace faulty components.

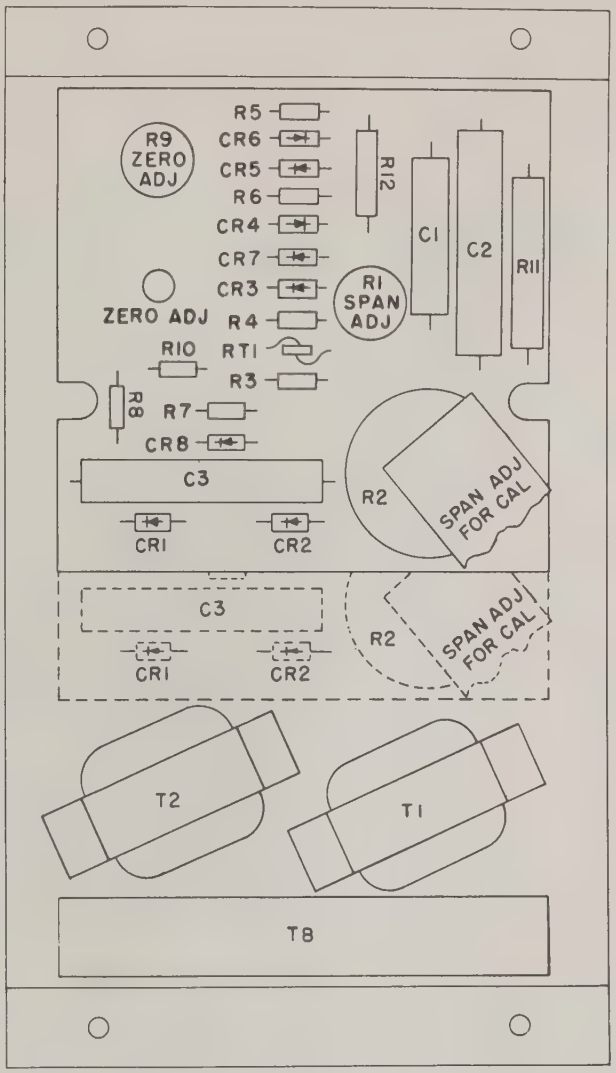


Fig. 14. Component location diagram

REPAIR PARTS

The repair parts list, in conjunction with Fig. 14, lists and illustrates replaceable electrical parts of the transducers described herein. The parts are identified by their reference designations. The quantities are given for both the single-element and double-element transducers. Both transducers use the same parts; however, the double-element transducer uses twice the number of electrical parts as does the single-element transducer.

Fig. No.	Ref. Desig. No.	Part No.	Description 1 2 3 4 5 6 7	Units Per Assy A (Single Element)	Units Per Assy B (Double Element)
14		50-470121AWAA1	WATT-VAR TRANSDUCER, Type 4701, Single element (See Units per Assy, column A)	1	
		50-470122AWAA1	WATT-VAR TRANSDUCER, Type 4701, Double element (See Units per Assy, column B)		1
	C1	2094K11-168	. CAPACITOR, Molded, paper, 0.068 ufd ±20%, 400Vdc (Sprague Electric Cat. No. 160P-68304 or equal)	1	2
	C2	2098K10-001	. CAPACITOR, Aluminum, Electrolytic, Non-polar - 100 ufd +75% -10%, 25Vdc (Sprague Electric Cat. No. 41D-31311 or equal)	1	2
	C3	2106K46-001	. CAPACITOR, Solid tantalum, 50 ufd, ±20%, 15V (Sprague Electric Cat. No. 151D506X0015Z2 or equal). . . .	1	2
	CR1, CR2	6705K90-011	. DIODE, SILICON, Type 1N647.	2	4
	CR3, CR4, CR5, CR6, CR7	*6705K42-001	. DIODE, SILICON, 10V, ±5%, Type 1N758, marked red, green, or yellow. . . .	5	10
	CR8	*6705K42-001	. DIODE, SILICON, 13.25V, ±5%, Type 1N717, marked red, green, or yellow.	1	2
	R1	5840K43-001	. POTENTIOMETER, 20 ohms (CTS Series 110-F2 or equal).	1	2
	R2	5840K44-001	. POTENTIOMETER, Wire wound, 80 ohms ±10%	1	2
	R3	6148K44-008	. RESISTOR, Wire wound, 110 ohms, ±0.1% 1 watt (Tel-Labs Cat. No. EL1A or equal)	1	2
	R4	6148K44-002	. RESISTOR, Wire wound, 368 ohms ±0.1% 1 watt (Tel-Labs Cat. No. EL1A or equal)	1	2

*Selected parts. When ordering, include both voltage rating and color code. Replacement parts must have identical color code.

Fig. No.	Ref. Desig. No.	Part No.	Designation 1 2 3 4 5 6 7	Units Per Assy A (Single Element)	Units Per Assy B (Double Element)
14	R5	6148K44-005	. RESISTOR, Wire wound, 1100 ohms ±0.1% 1 watt (Tel-Labs Cat. No. EL1A or equal)	1	2
	R6	6148K44-004	. RESISTOR, Wire wound, 517 ohms ±0.1% 1 watt (Tel-Labs Cat. No. EL1A or equal)	1	2
	R7	6148K44-001	. RESISTOR, Wire wound, 385 ohms ±0.1% 1 watt (Tel-Labs, Cat. No. EL1A or equal)	1	2
	R8	6148K44-003	. RESISTOR, Wire wound, 500 ohms ±0.1% 1 watt (Tel-Labs, Cat. No. EL1A or equal)	1	2
	R9	5840K43-003	. POTENTIOMETER, 30 ohms (CTS Series 110-F2 or equal)	1	2
	R10	6148K44-003	. RESISTOR, Wire wound, 500 ohms ±0.1% 1 watt (Tel-Labs, Cat. No. EL1A or equal)	1	2
	R11	6148K44-006	. RESISTOR, Wire wound, 150 ohms ±1% 5 watts (Tel-Labs, Cat. No. EL5 or equal)	1	2
	R12	6148K44-007	. RESISTOR, Wire wound, 310 ohms ±0.1% 5 watts (Tel-Labs, Cat. No. EL5 or equal)	1	2
	RT1	8381K11-008	. THERMISTOR, Disc, 250 ohms ±10% at 25C (General Electric Cat. No. 1D403)	1	2
	T1	8613K10-001	. TRANSFORMER, Potential, 120V, 0.60 amps primary; center-tapped secondary, with rating of 66V ±1.0V rms to each end. Both secondaries must be within 1½% of each other. Nominal d-c resistance: primary winding - 170 ohms; secondary winding - 75 ohms, center tap to either end. (BTC Cat. No. 3999 or equal) .	1	2
	T2	8604K10-001	. TRANSFORMER, Current, 5 amps primary; 0.05 amps ±3.0% secondary. Nominal d-c resistance: primary winding - 0.015 ohms; secondary winding - 177 ohms. (BTC Cat. No. 4000 or equal).	1	2

Fig. No.	Ref. Desig. No.	Part No.	Designation 1 2 3 4 5 6 7	Units Per Assy A (Single Element)	Units Per Assy B (Double Element)
14	TB	1594K16-002	. TERMINAL BOARD, Molded barrier type, 12 poles (H.B. Jones Cat. No. 12-164-3/4W or equal)	1	1
		5194K10-008	. MARKER STRIP.	1	1
		3829K22-007	. GASKET, Cover, rubber	1	1

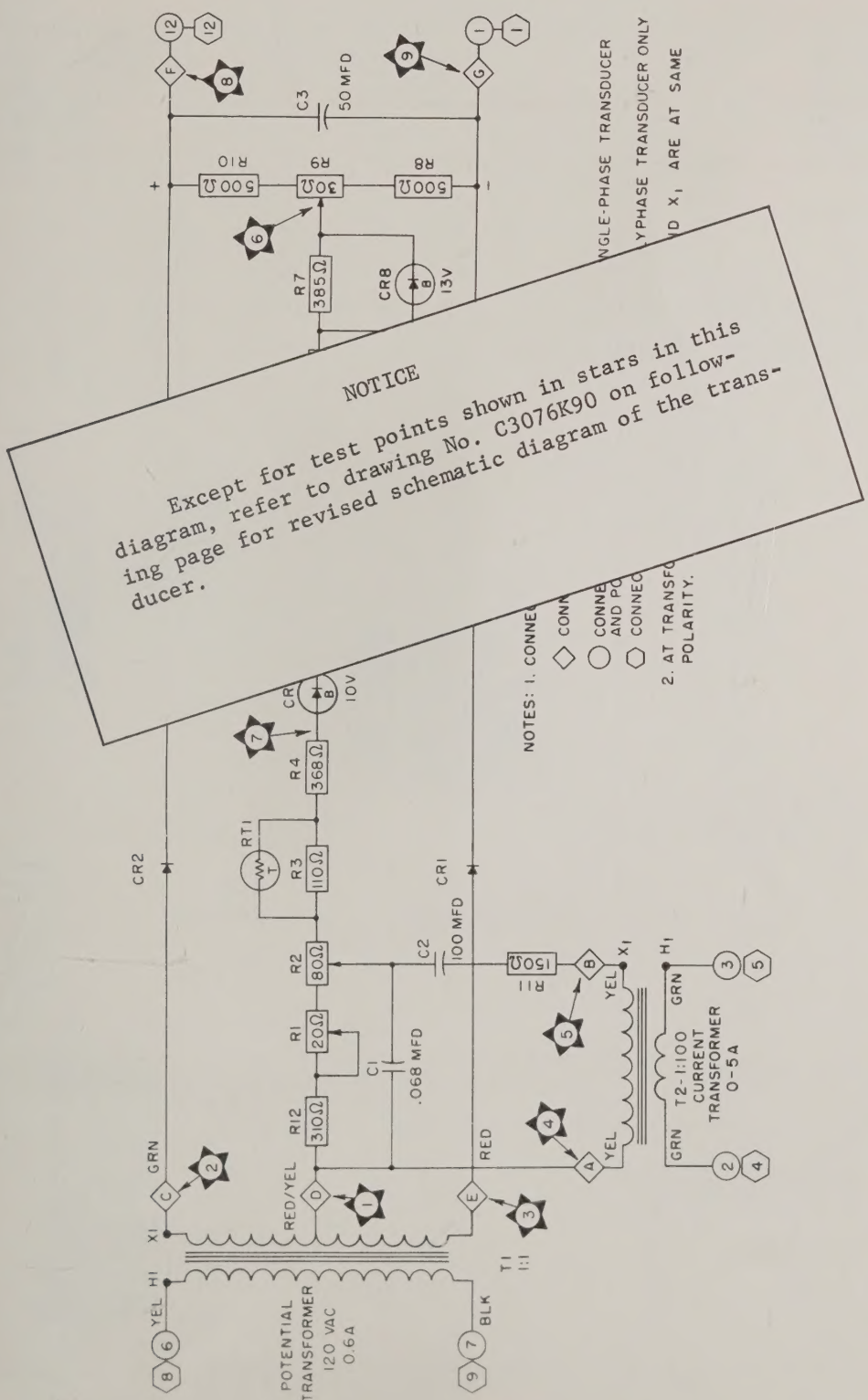
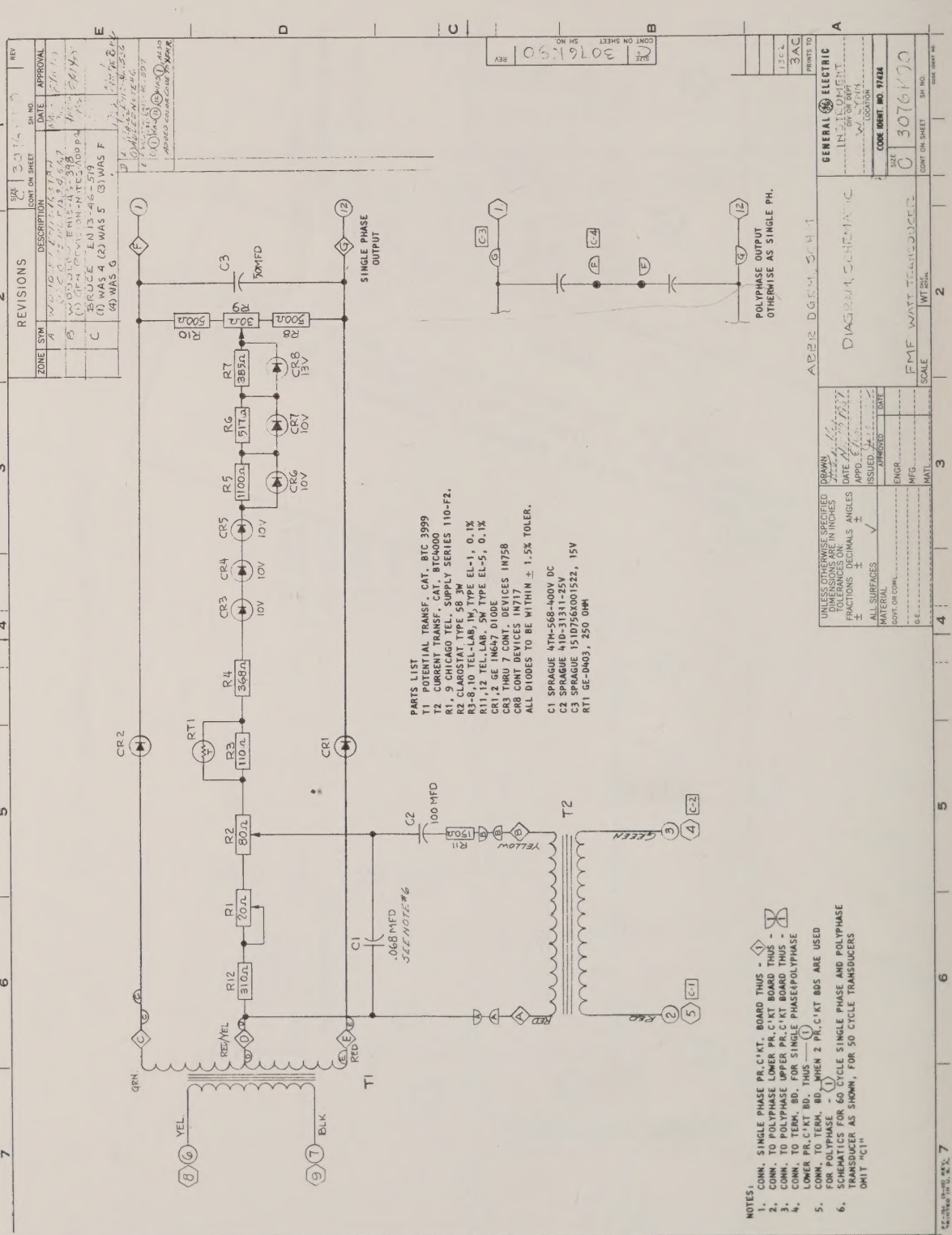


Fig. 15. Schematic wiring diagram


PARTS LIST
T1 POTENTIAL TRANSF. CAT. BTC 3999
T2 CURRENT TRANSF. CAT. BTC4000
R1, 9 CHICAGO TEL. SUPPLY SERIES 110-F2.
R2 CLAROSTAT TYPE 58 3W
R3-8,10 TEL-LAB, 1W, TYPE EL-1, 0.1%
R11,12 TEL.LAB. 5W TYPE EL-5, 0.1%
CR1,2 GE 1N647 DIODE
CR3 THRU 7 CONT. DEVICES 1N758
CR8 CONT DEVICES 1N717
ALL DIODES TO BE WITHIN ± 1.5% TOLER.
C1 SPRAGUE 47TM-568-400V DC
C2 SPRAGUE 41D-31311-25V
C3 SPRAGUE 151D756X0015Z2, 15V
RT1 GE-D403, 250 OHM
NOTES:
1. CONN. SINGLE PHASE PR.C'KT. BOARD THUS - ◇
2. CONN. TO POLYPHASE LOWER PR.C'KT BOARD THUS - ⊠
3. CONN. TO POLYPHASE UPPER PR.C'KT BOARD THUS - ⊠
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5. CONN. TO TERM. BD. WHEN 2 PR.C'KT BDS ARE USED FOR POLYPHASE - ①
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